J. Raptor Res. 37(4):307–314

PRODUCTIVITY AND POPULATION TRENDS OF OSPREYS IN THE KAWARTHA LAKES REGION, ONTARIO, 1978–2001

SHANE R. DE SOLLA AND PAMELA A. MARTIN[1]
Canadian Wildlife Service, Environment Canada, Box 5050, 867 Lakeshore Road, Burlington ON, L7R 4A6 Canada

PETER J. EWINS
World Wildlife Fund, 245 Eglington Avenue E., Toronto, ON M4P 3J1 Canada

MICHAEL E. BARKER
Wetland Habitat Fund, 1289 Algonquin Blvd. Peterborough, ON K9H 6N1 Canada

ABSTRACT.—Osprey (*Pandion haliaetus*) populations were monitored extensively in the Kawartha Lakes region of Ontario, Canada, from 1978–2000, and intensively monitored in a subsample of these lakes, particularly Sturgeon Lake, (1991–2001). The number of occupied nests within the Kawartha Lakes region increased from 18 nests in 1978 to 89 nests in 1992 following the ban of organochlorine pesticides and the provision of artificial nesting structures. Surveys in 1996 and 2000, however, revealed 78 and 66 occupied nests, respectively, indicating a recent population decline or stabilization. The Osprey breeding colony at Sturgeon Lake followed very similar trends in nest numbers, peaking in the mid-1990s, followed by a decline and apparent population stabilization by 2001. The mean annual productivity in this colony between 1986 and 2001 was 1.17 chicks per occupied nest, and exceeded the reported replacement level of 0.8 chicks per nest. Population fluctuations and trends in overall annual production of fledglings were similar between the Sturgeon Lake breeding colony and birds breeding at lower densities in neighboring lakes. Estimated potential recruitment to the Sturgeon Lake colony, based on the number of fledglings produced 3–5 years previously, was positively related to population size in a given year ($r^2 = 0.65$); but very few banded nestlings returned to the colony as breeders. Factors affecting productivity and population trends seem to operate similarly at local and regional scales. As very few fledged juveniles returned to the Sturgeon Lake colony as breeders, yet the population was maintained, we suggest there was probably considerable dispersal of juveniles among local natal sites throughout the region.

KEY WORDS: *Osprey;* Pandion haliaetus; *Ontario; population; productivity.*

PRODUCTIVIDAD Y TENDENCIAS POBLACIONALES DE ÁGUILAS PESCADORAS EN LA REGIÓN DE LOS LAGOS KAWARTHA, ONTARIO, 1978—2001

RESUMEN.—Las poblaciones de Águila pescadora (*Pandion haliaetus*) fueron monitoreadas extensivamente en la región de los lagos Kawartha de Ontario, Canadá, desde 1978–2000, y monitoreadas intensivamente en una submuestra de estos lagos, particularmente en el Lago Esturión, (1991–2001). El número de nidos ocupados dentro de la región de los lagos Kawartha incremento desde 18 nidos en 1978 a 89 nidos en 1992 luego de la prohibición de los pesticidas organoclorados y de proveer estructuras artificiales para anidación. Los estudios en 1996 y 2000 sin embargo, revelaron 78 y 66 nidos ocupados, respectivamente, indicando un reciente declive en la población o su estabilización. La colonia de anidación del águila pescadora en el Lago Esturión siguió tendencias muy similares en el numero de nidos, alcanzando su pico a mediados de los 90s, seguido por un declive y una aparente estabilización de la población para el 2001. la productividad media anual en esta colonia entre 1986 y 2001 fue 1.17 polluelos por nido ocupado, y excedió el nivel de reposición reportado de 0.8 polluelos por nido. Las fluctuaciones de la población y las tendencias en la producción anual global de juveniles fueron similares entre la colonia de anidación del Lago Esturión y las aves que anidaron en más bajas densidades en lagos vecinos. El reclutamiento potencial estimado para la colonia del Lago Esturión, basada en los números de juveniles producidos 3–5 años atrás, se relacionó positivamente con el tamaño de la pobla-

[1] Corresponding author's e-mail address: pamela.martin@ec.gc.ca

ción en un año dado (r^2 = 0.65); aunque, muy pocos juveniles anillados retornaron a la colonia como reproductores. Los factores que afectan la productividad y las tendencias poblacionales parecen operar similarmente a escalas locales y regionales. A pesar que muy pocos de los juveniles levantados retornaron a la colonia del Lago Esturión como reproductores, aun la población se mantuvo, sugerimos que allí probablemente hubo una considerable dispersión de juveniles entre los sitios natales locales de toda la región.

[Traducción de César Márquez]

Osprey (*Pandion haliaetus*) populations, like those of many fish-eating birds throughout North America, declined due to pesticide-related effects in the 1950s and 1960s, subsequently recovering following restrictions in the use of organochlorine pesticides and other chlorinated hydrocarbons in the early 1970s (Spitzer et al. 1983, Ewins et al. 1995, Houghton and Rymon 1997). Many programs have been implemented to monitor Osprey populations in North America and to improve recruitment (Spitzer et al. 1983, Steidl et al. 1991, Castellanos and Ortega-Rubio 1995, Ewins 1996, Witt 1996).

In 1978, the Ontario Ministry of Natural Resources began monitoring the Osprey population of the Kawartha Lakes region of south-central Ontario within the lower Great Lakes basin. Once common throughout the area, this population suffered a decline during the previous decades and the main objectives at that time were to assess and monitor population trends, and to enhance population growth and reproductive success through the creation of artificial nesting sites (Barker 1986, 1988). In 1991, the Canadian Wildlife Service initiated a study to assess the suitability of Ospreys as indicators of chlorinated hydrocarbon contaminants within the Great Lakes basin, as well as to determine if Ospreys breeding on the Great Lakes were continuing to suffer any adverse effects of these contaminants (Ewins et al. 1995, Martin et al. 2003). Ospreys on several lakes within the Kawartha Lakes system were also monitored to provide comparative data on what was assumed to be a clean inland breeding population. However, PCB concentrations in the eggs and plasma of nestling Ospreys in Sturgeon Lake were found to be considerably higher than those of birds nesting on the Canadian Great Lakes and in the Kawartha Lakes region (Martin et al. 2003). By 1996, when it had been demonstrated that contaminant levels were low elsewhere in the study area, the Canadian Wildlife Service ceased Osprey monitoring activities in the Great Lakes basin except in the Sturgeon Lake colony, where monitoring was continued until 2001.

We report here the population growth and fluctuations of Ospreys in the Kawartha Lakes region from 1978–2001 including data from survey reports from Ontario Ministry of Natural Resources from 1978–91 with those collected by the Canadian Wildlife Service and Kawartha Lakes Friends of the Osprey Society from 1991–2001. As well, we examine post-recovery patterns of productivity and adult returns of Ospreys in a selected small breeding colony.

STUDY AREA AND METHODS

The study area was primarily within the Kawartha Lakes region in south-central Ontario, a transitional zone bordering the Canadian Shield and the Great Lakes-St. Lawrence Lowlands ecozones (Fig. 1). This area consists of a chain of 17 shallow, mainly eutrophic lakes interconnected by a series of rivers and man-made canals. The water levels are controlled in some areas through the use of dams, and the littoral regions of some lakes were flooded as a result of the construction of the Trent-Severn Waterway over the last two centuries. Although the total area is approximately 6600 km^2, much of this land is under agricultural use and unsuitable Osprey habitat.

The entire Kawartha Lakes region, as well as adjoining portions of the Trent-Severn Waterway including Scugog Lake, the Otonabee River, and Rice Lake, were searched for Osprey nests by Ontario Ministry of Natural Resources in 1978–80, 1985, 1986, 1988, and 1991, and by the Canadian Wildlife Service in 1992. Suitable nesting habitat was searched in early June along routes with known nest sites, both by boat and by vehicle on roads near the lakes. Nest checks were done with a spotting scope or an extendible pole with an attached mirror. Second visits in July were made to nests throughout the region in 1986, 1988, and 1991; we calculated productivity on a per nest basis for these years (M. Barker unpubl. data). In 1988, 1991, 1996, and 2000, the entire region was also surveyed by fixed-wing aircraft from which nests may be viewed easily (Fuller and Mosher 1987), during the nestling period (mid-June). Furthermore, we had access to nest site information collected by local Osprey enthusiasts. Thus, we believe that the majority of occupied Osprey nests in the Kawartha Lakes region were located during these surveys.

A subset of Kawartha Lakes at the northwest end of the chain, including Sturgeon, Balsam, Canal, and Mitchell lakes, and Emily Creek (44°36′N, 7°20′W to 44°36′N, 79°05′W; Fig. 1) were surveyed annually by boat from

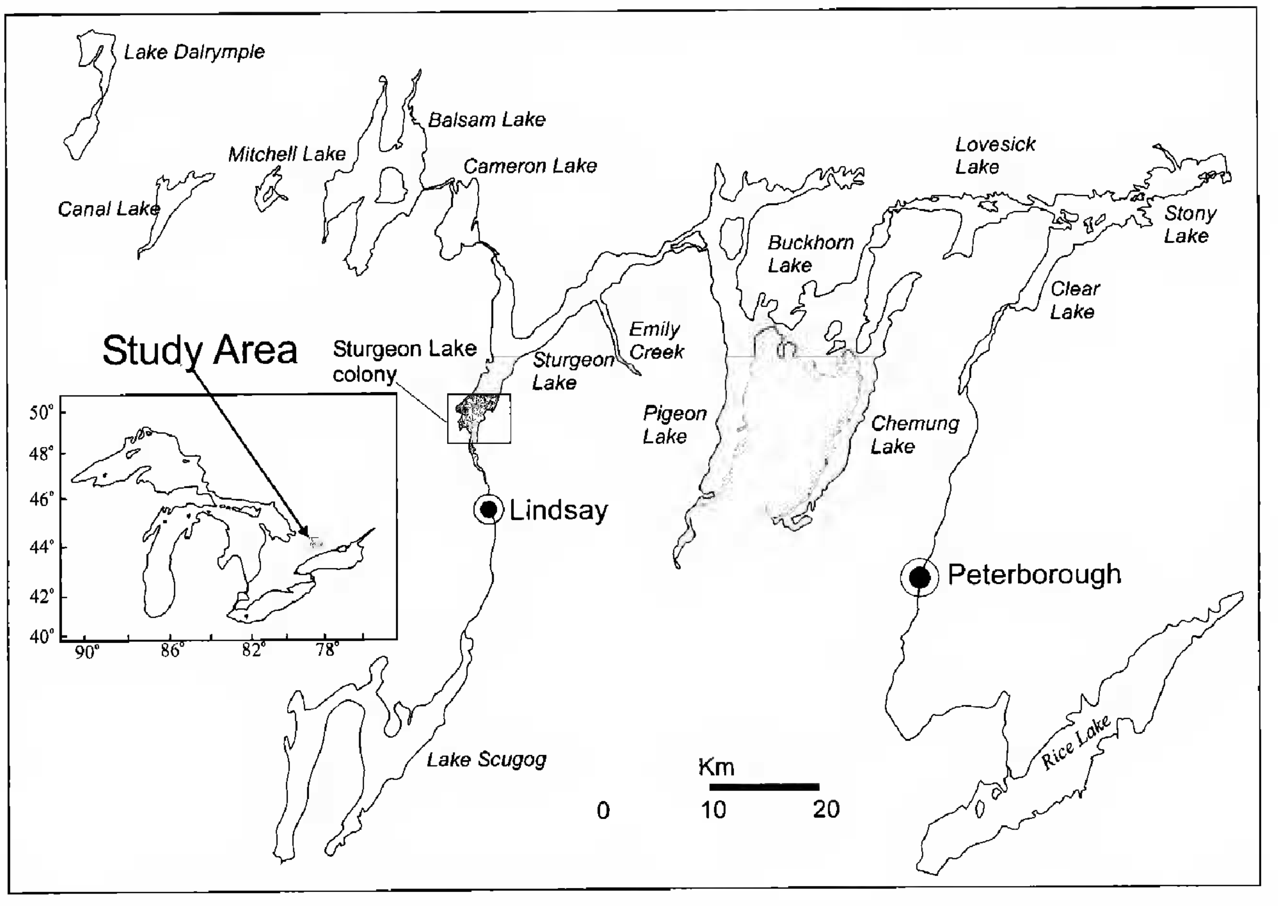

Figure 1. Kawartha Lakes study area indicating its position in the Great Lakes basin and the Sturgeon Lake Osprey breeding colony.

1991–96. The south end of Sturgeon Lake near the town of Lindsay was the site of a fairly dense nesting "colony" of Ospreys, in which up to 17 occupied nests occurred within a 3.5 km radius. In 1991, PCB contaminant levels in this colony were determined to be unusually high (egg x = 7.1 ppm; range: 2.02–26.5 ppm wet weight), and thus intensive annual monitoring in this colony continued until 2001.

Ospreys in Sturgeon Lake and the other northwestern lakes nested mostly on flooded stumps, whose tops were within a meter of the water, and on man-made elevated platforms, although some nests were located on live or dead trees and utility poles (P. Martin unpubl. data). All known nests on each lake were visited twice a year by boat. The first visit was made in late May or early June, during mid- to late incubation, and was a check for nest occupancy. We did not visit during the laying period or early incubation to avoid causing nest abandonment. Thus, it was possible some nests were destroyed before our initial visit, but this probability remained constant among years and probably did not represent a bias in monitoring. The second visit was in late June or early July when the chicks were 5–6 wk old (banding age). At this time we banded nestlings with both a US Department of Interior issued aluminum numeric band and a single colored plastic band. Each color of plastic band indicated a yearly cohort, and was used by all Osprey banding projects throughout the Great Lakes. The number of chicks remaining in the nest at this time were considered to be fledged although it is possible that some mortality may have occurred between banding and nest departure.

The occupied nest (ON) was used as the census unit, and was defined as a nest attended by a pair of Ospreys, regardless of any breeding attempt. Therefore, an occupied nest was considered equivalent to a pair of potential breeders. A successful nest was one in which at least one young was reared to banding age. Productivity rate was defined as the number of chicks reared to banding age per occupied nest. Production was the total number of chicks fledged in the overall population or group (Steenhof and Kochert 1982). We calculated the adjusted recruitment productivity (ARP), which is an estimate of the potential for new breeders in a given year (Spitzer 1980, Spitzer et al. 1983). Spitzer et al. (1983) calculated that 50% of Ospreys first bred at 3, 30% at 4, and 20% at 5 yr of age. Thus, the number of potential breeders recruited into the population in a given year was weighted by these proportions for the number of fledglings 3, 4, and 5 yr prior, using the equation:

$$[1] \qquad (0.5 \times Y_{t-3} + 0.3 \times Y_{t-4} + 0.2 \times Y_{t-5}),$$

where **Y** is the number of fledglings, and **t** is the year To convert recruitment to productivity, the weighted sum of fledglings was divided by the number of occupied nests the year before their recruitment, $\mathbf{O_{t-1}}$.

From 1992–96, most adults (all female) Ospreys at Sturgeon Lake were trapped using a dome-shaped noose carpet (Bloom 1987) tied over the nests during late incubation when nest-site tenacity was strong and chances of nest abandonment were low. The banding operation took less than 15 min and birds were always observed to return to their nest. Banded adults were of unknown age. Each year during the initial nest check, an effort was made to read the large 2-digit bands of breeding birds with 8 × 42 binoculars or a spotting scope. Birds were not recaptured on the nest for the purpose of determining their identity.

Data Analysis. We estimated changes in the size of the

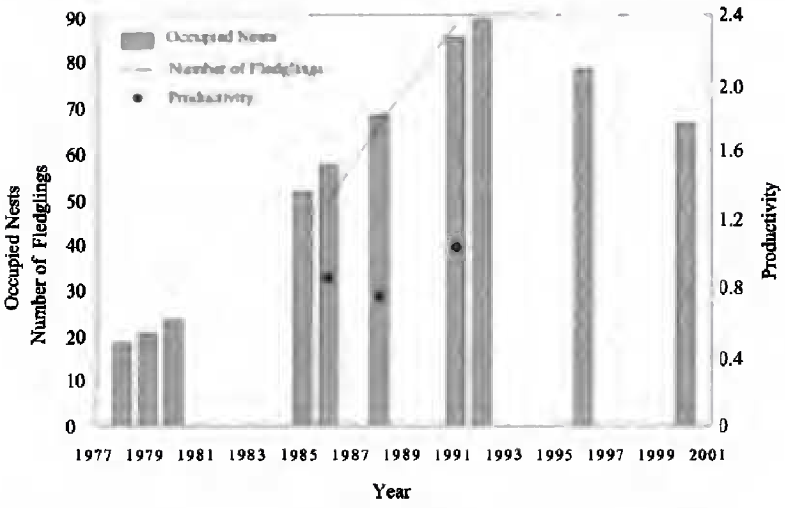

Figure 2. Productivity, number of occupied nests, and total number of Osprey fledged 1978–2001 in the entire Kawartha Lakes region, Ontario.

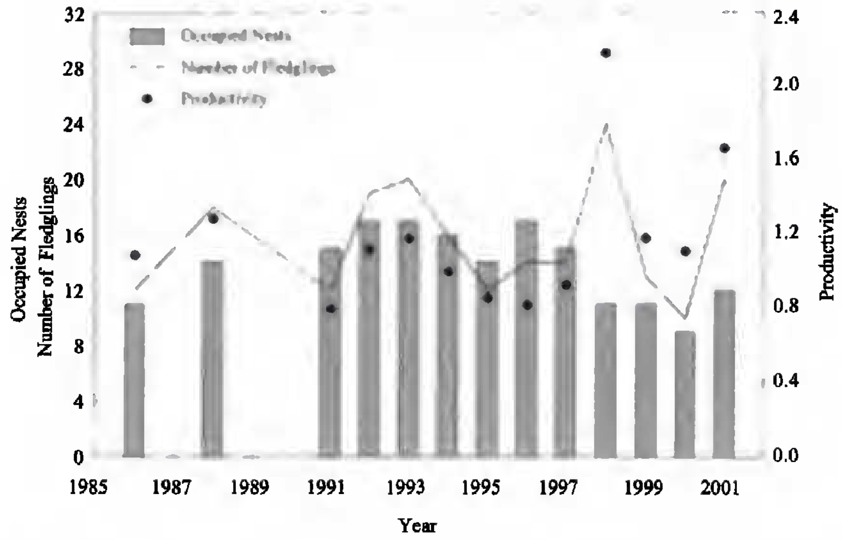

Figure 3. Productivity, number of occupied nests, and total number of Osprey fledged 1985–2001 at the Sturgeon Lake colony, Ontario.

Osprey population of the entire Kawartha Lakes region study area from 1978 onward, and in the Sturgeon Lake colony from 1986–2001, using least squares regression.

We evaluated the proportion of fledglings from Sturgeon Lake and the four neighboring lakes that later returned to breed. We included only juveniles that were banded from 1991–98, as juveniles fledged after 1998 would not be expected to breed until at least 2002. We compared recruitment and ARP with the annual percent change in population size using least squares regression. Only 6 yr of data (1996–2001) were available for analysis, as a minimum of 5 yr prior to the given year were required for the estimation of ARP. Data were insufficient for other areas within the Kawartha Lakes region to conduct this analysis. We calculated the encounter rates of adults in Sturgeon Lake from 1994–2001. The identities of breeding birds at each nest were tabulated from 1994 onward. Adults were identified by band numbers where possible, or were listed as either unbanded or unknown (band unreadable or unable to determine presence of band). The presence of plastic color bands was recorded.

Weather data were collected by Environment Canada at the Peterborough Airport from 1994–2001 and were accessed on the Ontarioweather webpage (Patrick 2002). For the months of May and June, we calculated the means for the daily mean, maximum, and minimum temperatures, windspeed, and dewpoint. We examined the relationships between spring weather variables and Osprey population dynamics at Sturgeon Lake.

RESULTS

Kawartha Lakes Region: Population Size. From 1978–92 there was a four-fold increase in the number of occupied nests throughout the Kawartha Lakes region study area (Fig. 2; r^2 = 0.997, $P <$ 0.001), representing a mean annual rate of increase of 10.3%; this rate of increase was greatest between 1980 and 1985 (15.9%). However, the population had declined 9% by 1996 and 22% by 2000, relative to maximum nest numbers of 1992.

Sturgeon Lake: Population Size. The number of occupied nests within the Sturgeon Lake colony increased from 11 in 1986 to 17 in both 1992 and 1993 (r^2 = 0.91, $F_{1,2}$ = 21.37, P = 0.04), fluctuated through 1996, then declined steadily to a low of nine in 2000, although there was a slight resurgence of nests in 2001 (r^2 = 0.69, $F_{1,7}$ = 15.31, P = 0.006; Fig. 3).

Sturgeon Lake: Productivity. Mean annual productivity at the Sturgeon Lake colony ranged from 0.8–2.18, with a mean of 1.17 fledglings per occupied nest (Fig. 3). There was no relationship between the total number of fledglings produced in the colony and the number of occupied nests in the same year, from 1986–2001 (r^2 = 0.05, P = 0.45); however, nest success was significantly related to mean annual per nest productivity (r^2 = 0.72, $P <$ 0.001). The percent change in population size was positively correlated to ARP (r^2 = 0.71, $F_{1,4}$ = 9.93, P = 0.035). Similarly, there was a positive relationship between potential recruitment and the population size (r^2 = 0.65, $F_{1,4}$ = 7.38, P = 0.053).

Detailed population and productivity data were available for Ospreys nesting at much lower densities in four adjacent lakes within the northwestern portion of the Kawartha Lakes (Balsam, Canal, and Mitchell lakes, and Emily Creek), providing a local comparison to the colony at Sturgeon Lake. The total number of occupied nests from these lakes ranged from 8–20 nests (Fig. 4). The population fluctuations observed in the Sturgeon Lake colony between 1986 and 2000 were similar to those in nearby lakes (r^2 = 0.44, P = 0.052) and both groups reached their lowest numbers in 2000. The annual changes in the total number of fledglings produced per year was similar between the

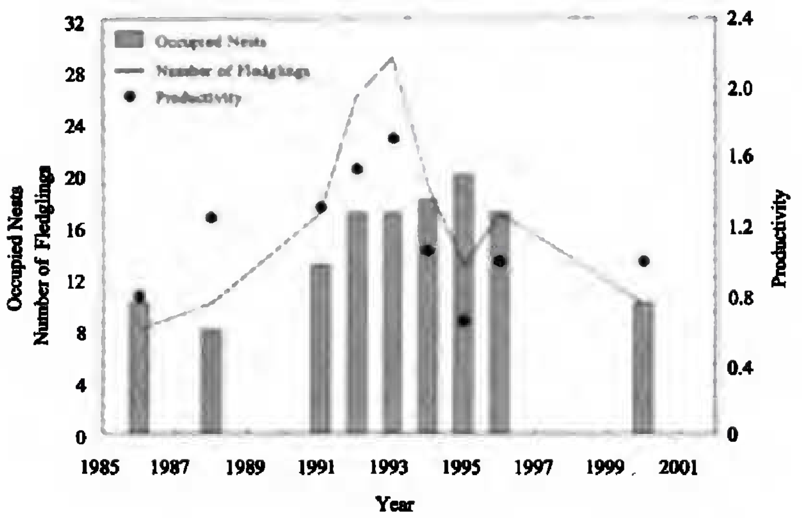

Figure 4. Productivity, number of occupied nests, and total number of Osprey fledged 1985–2001 at Balsam, Canal, and Mitchell lakes, and Emily Creek, Ontario.

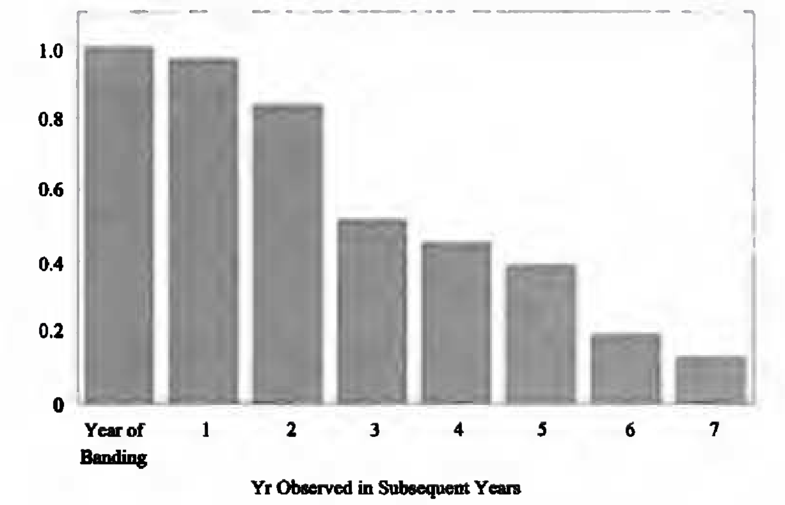

Figure 5. Cumulative proportion of banded adult Ospreys returning per year from year of banding.

Sturgeon Lake colony and the neighboring lakes ($r^2 = 0.51$, $F_{1,7} = 7.28$, $P = 0.03$; however, mean annual productivity per nest was not correlated between the two areas ($r^2 = 0.34$; $P = 0.17$). Nevertheless, mean annual productivity did not differ between the two groups pooled across years (dependent t-test, $t_8 = 1.73$, $P = 0.13$).

Resightings of Banded Juveniles. In the northwestern portion of the Kawartha Lakes a total of 179 chicks were banded between 1991 and 1998, and were thus available for recruitment into the breeding population by 2001, our last year of study. Only one bird banded as a juvenile was confirmed breeding at Sturgeon Lake; a total of three are known to have returned to the Kawartha Lakes region. As well, in 1997, a male Osprey that had been banded with a plastic color band as a juvenile in 1993 bred successfully at Sturgeon Lake. However, the natal location of this bird is unclear, as in 1993, color banding of annual cohorts was being conducted throughout the Great Lakes basin. Band recoveries were obtained for three other birds banded as juveniles. Two were found dead in their first autumn in Ohio and Michigan. The third was found dead on its wintering grounds in Lesser Antilles during its second winter.

Returns of Banded Adults. Of 18 adults banded at the nest in the Sturgeon Lake colony between 1992 and 1996, 15 were females. Two males returned to breed at the colony three years subsequent to banding, while one was only observed in the year of banding. Of the females, two bred at the colony only the year of banding and were not observed in subsequent years. There were pronounced declines in the proportion of adults returning on years 2 and 6 (Fig. 5). Females bred at the colony a modal frequency of 2 yr (six individuals) and a mean of 3.44 (SD = 2.09) years; seven was the maximum number of years females bred at the colony (two individuals). Thus, the modal minimum age at last breeding was 5 yr and the maximum age was 10 yr. Females with a high proportion of successful nests tended to have many breeding attempts ($r^2 = 0.64$, $F_{1,12} = 8.35$, $P = 0.014$). However, females were equally likely to be successful in the final year observed breeding (65.4%) than any other year of breeding (64.3%; $\chi^2 < 0.005$, $P = 0.97$). There was an equal probability that successful and unsuccessful females would switch nest sites the subsequent year ($\chi^2 = 2.23$, $P = 0.14$).

Effects of Weather. During the years 1994–2001, we found significant relationships between mean productivity of Ospreys in the Sturgeon Lake colony and weather conditions for May, but not for June. There was a significant positive relationship between productivity and mean daily temperature ($r^2 = 0.63$, $F_{1,6} = 10.41$, $P = 0.018$), mean maximum daily temperature ($r^2 = 0.48$, $F_{1,6} = 5.50$, $P = 0.058$), mean minimum daily temperature ($r^2 = 0.65$, $F_{1,6} = 11.30$, $P = 0.015$) and mean dewpoint ($r^2 = 0.67$, $F_{1,6} = 12.02$, $P = 0.013$). There were no significant relationships between productivity and mean, maximum, and gust wind speed.

DISCUSSION

Osprey populations throughout North America have rebounded from the declines of the mid-century induced by organochlorine pesticide exposure, following the ban on the use of these chemicals (Postupalsky 1989, Ewins et al. 1995, Henny and Kaiser 1996, Houghton and Rymon 1997). Although the Osprey population of the Kawartha

Lakes region in the lower Great Lakes basin has also expanded by four-fold from 1978–92, its status pre-DDT era is unknown. By the year 2000, however, this regional population had contracted to 74.2% of its maximum expansion achieved in 1992. Similar leveling off or slight decline of Osprey populations, following periods of rapid growth, has occurred elsewhere in the Great Lakes basin. Osprey populations increased dramatically during the post-DDT era in Michigan (Postupalsky 1989); however, during the latter half of the 1990s, populations in the Upper and Lower Peninsula declined by 22% and 9%, respectively (S. Postupalsky pers. comm.). An Oregon population experienced similar increases in size throughout the 1970s and 1980s as contaminant levels declined (Henny and Kaiser 1996). In contrast, instead of reaching a plateau, this population more than doubled from 1995–2001 (USGS 2002). The authors suspect that recent acceptance by the Ospreys of utility poles and channel markers as nesting sites accounts for this sudden population increase (USGS 2002), suggesting that appropriate nest sites were limiting previously. Sturgeon Lake appeared to have a surplus of established nesting sites. Given that there were always some unoccupied nest platforms, and that we frequently observed the construction of new nests on exposed stumps, it seems that availability of nest sites probably was not limiting this population of Ospreys. A common strategy in encouraging Osprey population expansion has been to erect artificial nest sites (Ewins 1996, Witt 1996). Our results suggest that even at high population densities, nest site availability was not a limiting factor. The Sturgeon Lake breeding colony seems to have reached a plateau and a management strategy based on further construction of artificial nests is unlikely to result in further growth. Nevertheless, there is anecdotal evidence (R. Skitch, Ontario Power Generation pers. comm.) that in the eastern section of the Kawartha Lakes region (Rice and Stoney lakes), there has been a dramatic increase in the use of utility poles in 2001 and 2002. This tendency to use utility poles may have facilitated an increase in the regional population overall.

Although the eggs of Sturgeon Lake Ospreys were found to contain relatively elevated egg PCB concentrations when examined in 1991–92, there was no apparent correlation between productivity with either DDE or PCB concentrations throughout the Canadian Great Lakes basin, including the Kawartha Lakes region (Martin et al. 2003). Unfortunately, there is neither contaminant nor population data available for Canadian Great Lakes Osprey from the 1960s and 1970s with which to document a causal relationship. Nevertheless, it is unlikely that current levels of contamination adversely impact reproduction in the Sturgeon Lake colony (Poole 1989).

The proportion of nests that were successful as opposed to the total number of nests occupied in a given year was strongly correlated to mean annual productivity, suggesting that the factors contributing to nest failure also affected partial mortality within a nest. Depredation was clearly evident for three complete clutches of eggs, whereas four complete broods of chicks were obviously depredated. Although only three Osprey nestlings were actually found dead in the nest at time of banding that were suspected to have died from starvation, there were many instances of partial brood reduction (in either the egg or nestling stage). In some cases, single unhatched eggs remained in the nest at banding, possibly as a result of infertility or inclement weather during incubation. The latter possibility is supported by the positive relationship between May temperatures and productivity. Flooding caused by storms, as well as controlled water level changes as a result of damming, are suspected to be the cause of destruction of nest contents in low, overwater stump nests (P. Martin, M. Barker, and B. Puxley unpubl. data). Other studies have also indicated that poor weather conditions impacted fledging success of Ospreys (Poole 1982, Machmer and Ydenberg 1990) but see Stinson (1978) and Stinson et al. (1987). Trends in annual production of successful fledglings were similar between Sturgeon Lake and the neighboring lakes, suggesting that regulatory factors (e.g., weather) operate at a scale that encompasses the entire Kawartha Lakes region in a given year.

Estimates of the productivity required to maintain stable populations for Ospreys ranged from 0.8 fledglings per nest (Spitzer et al. 1983) to between 1.22 and 1.30 (Henny and Ogden 1970). An important distinction between these studies (Spitzer et al. 1983, Henny and Ogden 1970) was that the populations studied had very different trajectories of growth. The population studied by Spitzer (1980) was recovering, while those examined by Henny and Ogden (1970) were generally declining. Nevertheless, 0.8 fledglings per nest is typically accepted as the productivity "break-even" point for Ospreys in the northeastern United States and

Canada (Ewins et al. 1995). This rate was met or exceeded in each of the 11 years of study at the Sturgeon Lake colony and in all but one year in the neighboring lakes. Adjusted recruitment productivity (ARP), which was based on fledgling production from 3–5 yr prior to any given year, was highly correlated with population size. Thus, reduced productivity from 1995 through 1997 directly correspond to declines in the breeding population from 1998 through 2000. Also, the sudden increase in productivity in 1998 corresponded to the increased breeding population of 2001.

The productivity "break-even" point does not account for differences in adult survivorship or dispersal. Although we banded adult birds we were unable to estimate longevity as the ages of the birds were unknown at time of banding. Of 15 adult females banded, two marked in 1992 were observed to breed on Sturgeon Lake for seven seasons. Assuming they were first time breeders when initially banded in 1992 and were 3 yr old at time of banding, these birds were a minimum of 10 yr old during their last known breeding year of 1998. Of 17 known-aged females who reached breeding age banded as nestlings in a recovering population in Michigan during the 1970s and 1980s, five reached or exceeded 10 yr of age whereas 12 died prior to attaining 10 yr of age (Postupalsky 1989). Thus, our rate of 13% of females exceeding 10 yr of age is lower than that of 35% in the Michigan birds, suggesting possible problems in adult survival, although data are limited.

Less than 2% of 179 fledglings that were banded in the northwestern portion of the Kawartha Lakes region from 1991–98 were later encountered breeding in the Kawartha region. After 1996, however, only the Sturgeon Lake colony was monitored intensively, so opportunities to observe banded birds were limited. Nevertheless, even at Sturgeon Lake, where 70% of all juveniles produced were banded over the 11 yr period, less than 3% of the 94 birds returned to this colony as breeders. This suggests that new breeders at the Sturgeon Lake colony arrived via dispersal from other natal sites, either in the Kawartha Lakes region or from more distant populations. The distances among the Kawartha Lakes are certainly within typical dispersal distances of Ospreys (Spitzer et al. 1983, Postupalsky 1989). That the adjusted recruitment productivity at Sturgeon Lake was highly correlated with population size, despite the fact that very few juveniles produced there actually return to the colony to breed, suggests that trends in localized groups of breeders are indicative of regional population fluctuations.

The growth of the Kawartha Lakes population of Ospreys has stabilized or slightly declined in the last decade, but as rates of productivity seem to be adequate for reproduction, we do not expect further declines. Factors affecting productivity and population trends appear to operate similarly at the local and regional scale. As very few fledged juveniles returned to the Sturgeon Lake colony as breeders, yet the population was maintained, we suggest there was probably considerable dispersal of juveniles among local natal sites throughout the region. Although we did not detect nest site limitation at the Sturgeon Lake colony, it is possible that recent observed increases in the usage of utility poles in another portion of the Kawartha Lakes region may have fostered population increases throughout the region.

ACKNOWLEDGMENTS

Funding for much of this work was supplied by The Ontario Ministry of Natural Resources and Environment Canada's Great Lakes Action Plan. M. Bacro, L. Benner, and G. Barrett provided assistance in the field. We are grateful for the Kawartha Lakes Friends of the Osprey Society for logistical support and for maintaining the artificial Osprey nest platforms. We would like to thank D. Patrick for the free access to the archived weather data from the Peterborough area. We would also like to thank the Otonabee Region Conservation Authority and the former Ontario Hydro and the present Ontario Power Generation for their cooperation. This manuscript was improved by comments from D. Weseloh, C. Henny, and two anonymous reviewers.

LITERATURE CITED

BARKER, M. 1986. Osprey nesting survey. Lindsay District. Unpublished report submitted to Ontario Ministry of Natural Resources. Lindsay, ON, Canada.

———. 1988. Osprey nesting survey. Lindsay District. Unpublished report submitted to Ontario Ministry of Natural Resources. Lindsay, ON, Canada.

BLOOM, P.H. 1987. Capturing and handling raptors. Pages 99–123 *in* B.A. Giron Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor management techniques manual, Natl. Wildl. Fed., Washington, DC U.S.A.

CASTELLANOS, A. AND A. ORTEGA-RUBIO. 1995. Artificial nesting sites and Ospreys at Ojo de Liebre and Guerrero Negro lagoons, Baja California Sur, Mexico. *J Field Ornithol.* 66:117–127.

EWINS, P.J. 1996. The use of artificial nest sites by an increasing population of Ospreys in the Canadian Great Lakes Basin. Pages 109–123 *in* D. Bird, D.E. Varland,

and J.J. Negro [EDS.], Raptors in human landscapes. Academic Press, London, U.K.

———, S. POSTUPALSKY, T. WEISE, AND E.M. ADDISON. 1995. Changes in the status, distribution and biology of Ospreys (*Pandion haliaetus*) breeding on Lake Huron. Pages 273–290 *in* M. Munawar, T. Edsall, and J. Leach [EDS.], The Lake Huron ecosystem: ecology, fisheries, and management. SPD Academic Publishing, Amsterdam, The Netherlands.

FULLER, M.R. AND J.A. MOSHER. 1987. Raptor survey techniques. Pages 37–65 *in* B.A. Giron Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor management techniques manual, Natl. Wildl. Fed., Washington, DC U.S.A.

HENNY, C.J. AND J.C. OGDEN. 1970. Estimated status of Osprey populations in the United States. *J. Wildl. Manage.* 34:214–217.

——— AND J.L. KAISER. 1996. Opsrey population increase along the Willamette River, Oregon, and the role of utility structures, 1976–1993. Pages 97–108 *in* D. Bird, D.E. Varland, and J.J. Negro [EDS.], Raptors in human landscapes. Academic Press, London, U.K.

HOUGHTON, L.M. AND L.M. RYMON. 1997. Nesting distribution and population status of U.S. Ospreys 1994. *J. Raptor Res.* 31:44–53.

MACHMER, M.M. AND R.C. YDENBERG. 1990. Weather and Osprey foraging energetics. *Can. J. Zool.* 68:40–43.

MARTIN, P.A., S.R. DE SOLLA, AND P.J. EWINS. 2003. Chlorinated hydrocarbon contamination in Osprey eggs and nestlings from the Canadian Great Lakes Basin, 1991–1995. *Ecotoxicology* 12:209–224.

PATRICK, D. 2002. Ontarioweather webpage. http://www.ontarioweather.com.

POOLE, A.F. 1982. Brood reduction in temperate and subtropical Ospreys. *Oecologia* 53:111–119.

———. 1989. Ospreys: a natural and unnatural history. Cambridge Univ. Press, Cambridge, U.K. and New York, NY U.S.A.

POSTUPALSKY, S. 1989. Osprey. Pages 297–313 *in* I. Newton [ED.], Lifetime reproduction in birds. Academic Press, London, U.K.

SPITZER, P.R. 1980. Dynamics of a discrete coastal breeding population of Ospreys in the northeastern United States during a period of decline and recovery, 1978. Ph.D. dissertation, Cornell University, Ithaca, NY U.S.A.

———, A.F. POOLE, AND M. SCHIEIBEL. 1983. Initial population recovery of breeding Ospreys in the region between New York City and Boston. Pages 231–241 *in* D.M. Bird [ED.], Biology and management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec, Canada.

STEENHOF, K. AND M.N. KOCHERT. 1982. An evaluation of methods used to estimate raptor nesting success. *J. Wildl. Manage.* 46:885–893.

STEIDL, R.J., C.R. GRIFFIN, AND L.J. NILES. 1991. Contaminant levels of Osprey eggs and prey reflect regional differences in reproductive success. *J. Wildl. Manage.* 55:601–608.

STINSON, C.H. 1978. The influence of environmental conditions on aspects of the time budgets of breeding Ospreys. *Oecologia* 36:127–139.

———, J. LAUTHNER, AND R.T. RAY. 1987. The effect of weather conditions on the behavior of Ospreys in northwestern Washington. *Can. J. Zool.* 65:2116–2118.

USGS. 2002. Ospreys in Oregon and the Pacific Northwest. USGS FS-153-02, U.S. Department of Interior, U.S. Geological Survey, Corvallis, OR U.S.A.

WITT, J.W. 1996. Long-term population monitoring of Osprey along the Umpqua River in western Oregon. *J. Raptor Res.* 30:62–69.

Received 20 December 2002; accepted 17 June 2003
Associate Editor: Marco Restani